If you are using a printed copy of this procedure, and not the on-screen version, then you MUST make sure the dates at the bottom of the printed copy and the on-screen version match.
The on-screen version of the Collider-Accelerator Department Procedure is the Official Version.
Hard copies of all signed, official, C-A Operating Procedures are kept on file in the C-A ESHQ Training Office, Bldg. 911A.

C-A OPERATIONS PROCEDURES MANUAL

14.10 C-A EMS Process Assessment for Cryogenic System Maintenance (RHIC-530-CSM)

Text Pages 2 through 11

Attachments

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Approved: ***Signature on File*** _____
Collider-Accelerator Department Chairman Date

J. Scott

BROOKHAVEN NATIONAL LABORATORY
PROCESS ASSESSMENT FORM

I. General Information

Process ID:	RHIC-530-CSM			
Process Name:	Cryogenic System Maintenance			
Process Flow Diagrams:	RHIC-530-CSM-01 through 04			
Process Description:	The process includes the maintenance operations for the Cryogenic Systems managed by the Collider-Accelerator Department located in Buildings 1005R, 1005H, the valve box locations at 1012A, 1002B, 1004B, 1006B, 1008B and 1010A and the Liquid Helium Storage System and associated compressor in 1005E. The cryogenic system located in Buildings 1005R, and 1005H, supplies supercritical helium and liquid helium to the RHIC ring. Cryogenic maintenance includes the routine replacement of oil and servicing of vacuum pumps; replacement of shaft seals in compressors; and, maintenance of the helium purifying systems (coalescers, mist eliminators, activated carbon). Section II and the above-referenced Process Flow Diagrams provide more detail on the Cryogenic System Maintenance procedures.			
Dept./Div.:	Collider-Accelerator Department			
Dept. Code:	AD			
Building(s):	1005R, 1005H, 1005E, 1006B and associated valve box locations			
Room(s):	N/A			
Point of Contact:	A. Etkin J. Scott A. Warkentien	X4006 X7520 X3140		
Originally Prepared by:	D&B, G. Goode	Original Reviewers:	S. Musolino, L. Bower, J. Williams, R. Lee	
Initial Release Date:	12/31/98			

II. Detailed Process Descriptions and Waste Determination

The maintenance of the Cryogenic Systems managed by the Collider-Accelerator Department and located in Buildings 1005R, 1005H, 1005E, 1006B and the valve box locations have been organized into 5 major processing units, labeled 1.0 through 5.0. Process Flow Diagrams RHIC-530-CSM-01 through 04 provided in Attachment 1, graphically depict the process inputs and outputs for the Cryogenic System Maintenance operations.

The RHIC Ring is a 2.5-mile circumference particle collider located in the north central portion of BNL. The RHIC uses superconducting magnets to bend and focus the beam. The magnets are cooled to 4.6K supercritical helium gas. At cryogenic temperature, the magnets acquire superconducting properties, thereby greatly reducing the amount of electricity, which must be supplied to generate the magnetic field. Accelerated particles from counter rotating beams in separate rings are then steered into collision within a detector system. The detectors analyze and categorize the secondary particles resulting from the collision.

The cryogenic system located in Buildings 1005R (Refrigerator) and 1005H (Compressor Building) supplies supercritical helium gas to cool the collider magnets. A new Helium reliquifier system was installed in 1005E&1006B to maintain the liquid in storage tanks during long shutdowns. The ring cryogenic system typically operates continuously for 36 weeks per year.

In simplified terms, the cryogenic systems operate as follows: gaseous helium is compressed and routed through carbon purifiers to remove any contaminants. The Helium is then cooled through a heat exchanger and turbine system and both liquid helium and supercritical helium are produced.

Vacuum pumps are utilized to evacuate the enclosed space surrounding the cryogenic equipment and piping to prevent convective heat transfer. Maintenance operations include the routine replacement of vacuum pump oil and o-rings, gaskets and seals, as required. Vacuum pumps typically contain less than 5 gallons of oil.

Screw-type compressors are utilized to compress the gaseous helium for subsequent expansion into liquid and supercritical helium. The quantity of oil stored within the compressor varies depending on the size of the compressor. Oil for the compressors in Building 1005H is supplied from one approximately 300-gallon oil tank, which is located inside the building next to the oil purification system.. Note that the quantity of oil within the compressors and reservoirs is much less than the maximum capacity of the reservoirs and compressor oil is not changed as part of a routine maintenance schedule like vacuum pump oil.

In addition to the compressors utilized for compressing helium, the cryogenic system includes several compressors that are used as pumps and utility compressors. Each of the valve box locations has a utility compressor. The compressed air supplied to the valve boxes is required to be dry and oil free. Thus each is equipped with a dryer (General Pneumatics) and oil mist and oil/water separator ('Eliminator'). These compressors are smaller in size and do not hold large

quantities of oil. Other cryogenic system equipment which contains oil includes the following: rotoflow control skids used to adjust the speed on the turbine expanders; heat exchangers used to cool the oil from the compressors; and, an oil purifying system is used to purify compressor oil in Building 1005H.

When helium gas flows through the screw compressors some oil becomes entrained in the helium and must be removed prior to the helium entering the heat exchangers. From the compressor the helium passes through a series of coalescers (coarse filters), mist eliminators (fine filters) and molecular sieves (activated charcoal often referred to as charcoal beds). Oil removed from the helium in the coalescers and mist eliminators is collected in a trap and returned to the compressor reservoirs as part of a closed loop system.. Oil, if any, which is removed from the helium by the molecular sieve, is removed when the material is regenerated.

The primary chemicals used during cryogenic system maintenance are cleaners and degreasers. Ethyl alcohol is widely used to clean vacuum parts, as is LPS PreSolve and LPS Precision Cleaner. “Simple Green”, an environmentally “friendly” cleaner, is used wherever possible and is dispensed from large containers into re-fillable pump spray bottles. Occasionally, acetone is used where other cleaners have proven ineffective. Rags used in cleaning with acetone are allowed to air dry before disposal as industrial waste. The vacuum pumps utilize Plus 19 oil and the compressors utilize UCON LB-170 oil. Waste generated by the cryogenics system maintenance includes used oil and oily rags/debris.

Regulatory Determination of Process Outputs

1.0 Vacuum Pumps and Compressors

Building 1005R contains 12 vacuum pumps. Building 1005H contains 4 vacuum pumps and 24 screw compressors. Each of the six valve box locations has a screw compressor and associated dryer and oil/water separator.

Vacuum pumps are serviced on a routine basis, which involves changing the oil and replacing o-rings, gaskets and seals as needed. Screw compressors are serviced to replace the leaking shaft seals. Spill diapers are placed around the equipment while the oil is drained and new oil is added. Only the vacuum pump oil is completely replaced. Oil is removed from the compressors only to facilitate replacement of the shaft seals. Oil that has collected in drip pans beneath the screw compressors is also placed in the used oil drum. Oily paper rags and diapers used during maintenance activities are placed in an oily rag drum and transferred to the HWMF for disposal as industrial waste. Non-oily rags and empty cleaner (LPS PreSolve) containers are discarded in the regular trash. Worn o-rings, gaskets and shaft seals that are oil-free are discarded in the regular trash. If oily, worn o-rings, gaskets and shaft seals are placed in the oily rag drum. Removed carbon seals are cleaned and then placed in the metal chip bin for off-site recycling along with any scrap metal from removed parts. It should be noted that when carbon seals are replaced the activity is usually performed by the C-A Vacuum Group. The Cryogenic Systems only performs this activity when the Vacuum Group is unavailable.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
1.1	Used oil	Non-hazardous solid waste as determined by process knowledge	Waste is burned as fuel if it meets the criteria for burning, if not, it is drummed and sent to the HWMF for disposal as industrial waste	None
1.2	Oily rags, diapers, o-rings, gaskets and shaft seals	Non-hazardous solid waste as determined by process knowledge	Waste is drummed and sent to the HWMF for disposal as industrial waste	None
1.3	Non-oily rags, o-rings, gaskets, and shaft seals	Non-hazardous solid waste as determined by process knowledge	Waste is discarded in the regular trash	None
1.4	Carbon seals and scrap metal	Non-hazardous solid waste as determined by process knowledge	Waste is placed in the segregated chip bins for off-site recycling	None
1.5	Empty LPS PreSolve containers	Non-hazardous solid waste as determined by process knowledge	Waste is discarded in the regular trash	None

2.0 and 3.0 Coalescers, Mist Eliminators and Molecular Sieves

The cryogenic system in Buildings 1005H and 1005S use coalescers (coarse filters), mist eliminators (fine filters) and/or molecular sieves, (activated carbon, often referred to as charcoal beds) to remove contaminants from helium. Coalescers, mist eliminators and/or molecular sieves are utilized to remove oil entrained in the helium from the screw compressors during compression. Purifiers comprising of molecular sieves jacketed in liquid nitrogen are utilized to remove impurities from helium gas received from off-site vendors.

The attached process flow diagram depicts the process units and all the possible inputs and outputs for each unit based on the above variations of purifying systems. The diagram does not represent one particular system but is a combination of all of the above. The purifying systems were combined for the purposes of this PAF as the wastes generated are based on the type of unit(s) in the purifying system.

Oil removed from the helium in the coalescers and mist eliminators is collected in traps and returned to the compressor reservoirs as part of a closed loop system. If the filter material with the coalescer or mist eliminator becomes saturated, it must be replaced. The spent charcoal is packaged and sent to an off-site recycler. However, filters do not require replacement often. Oil, if any, which is removed from the helium by the molecular sieve, is removed when the material is regenerated. The molecular sieve is regenerated in place by heating the material so that water and other impurities adhered to the material will melt and collect in a trap at the bottom of the unit. The contaminated oily water is collected in a drum and transferred to the HWMF for disposal as industrial waste. It should be noted that, while the capability to regenerate exists, there is rarely a need to regenerate the molecular sieves.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
2.1	Saturated filters	Non-hazardous solid waste as determined by process knowledge	Waste is drummed and sent to an off-site recycler	None
2.2	Oily water	Non hazardous liquid as determined by process knowledge	Waste is drummed and sent to the HWMF for disposal as Industrial waste	None

4.0 Helium Reliquifier

A helium reliquifier has been installed at RHIC to reliquify helium boil-off from storage dewars during RHIC shutdown periods. The equipment is located in Buildings 1005E, 1006B with controls located in Building 1005H. The compressor and helium purifier are located in 1005E, the refrigerator in 1006B and liquid helium storage outside of building 1006B. The compressor used in the reliquification process has a reservoir that contains 90 gallons of UCON LB 170 heat transfer fluid.

Operations in the Helium Reliquifier are similar to those found in other Cryogenic operations. Vacuum pumps are serviced on a routine basis, which involves changing the oil and replacing o-rings, gaskets and seals as needed. Screw compressors are serviced, periodically, to replace the leaking shaft seal. Spill diapers are placed around the equipment while the oil is drained and new oil is added. Only the vacuum pump oil is completely replaced. Oil is removed from the compressors only to facilitate replacement of the shaft seals. Oil that has collected in drip pans beneath the screw compressors is also placed in the used oil drum. Oily paper rags and diapers used during maintenance activities are placed in an oily rag drum and transferred to the HWMF for disposal as industrial waste. Non-oily rags and empty cleaner (LPS PreSolve) containers are discarded in the regular trash. Worn o-rings, gaskets and shaft seals that are oil-free are discarded in the regular trash. If oily, worn o-rings, gaskets and shaft seals are placed in the oily rag drum. Removed carbon seals are cleaned and then placed in the metal chip bin for off-site recycling along with any scrap metal from removed parts. It should be noted that when carbon seals are replaced the activity is usually performed by the C-A Vacuum Group. The Cryogenic Systems only performs this activity when the Vacuum Group is unavailable.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
4.1	Used oil	Non-hazardous solid waste as determined by process knowledge	Waste is burned as fuel if it meets the criteria for burning, if not, it is drummed and sent to the HWMF for disposal as industrial waste	None

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
4.2	Oily rags, diapers, o-rings, gaskets and shaft seals	Non-hazardous solid waste as determined by process knowledge	Waste is drummed and sent to the HWMF for disposal as industrial waste	None
4.3	Non-oily rags, o-rings, gaskets, and shaft seals	Non-hazardous solid waste as determined by process knowledge	Waste is discarded in the regular trash	None
4.4	Carbon seals and scrap metal	Non-hazardous solid waste as determined by process knowledge	Waste is placed in the segregated chip bins for off-site recycling	None
4.5	Empty LPS PreSolve containers	Non-hazardous solid waste as determined by process knowledge	Waste is discarded in the regular trash	None

The attached process flow diagram depicts the process units and all the possible inputs and outputs for each unit. The diagram does not represent one particular system but is a combination of all of the cryogenic systems. The purifying systems were combined for the purposes of this PAF as the wastes generated are based on the same type of unit(s) in the purifying system.

Oil removed from the helium in the coalescers and mist eliminators is collected in traps and returned to the compressor reservoirs as part of a closed loop system. If the filter material with the coalescer or mist eliminator becomes saturated, it must be replaced. The spent charcoal is packaged and sent to an off-site recycler. However, filters do not require replacement often. Oil, if any, which is removed from the helium by the molecular sieve, is removed when the material is regenerated. The molecular sieve is regenerated in place by heating the material so that water and other impurities adhered to the material will melt and collect in a trap at the bottom of the unit. The contaminated oily water is collected in a drum and transferred to the HWMF for disposal as industrial waste. It should be noted that, while the capability to regenerate exists, there is rarely a need to regenerate the molecular sieves.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
4.6	Saturated filters	Non-hazardous solid waste as determined by process knowledge	Waste is drummed and sent to an off-site recycler	None
4.7	Oily water	Non hazardous liquid as determined by process knowledge	Waste is drummed and sent to the HWMF for disposal as Industrial waste	None

5.0 RHIC 80K Cooler

The RHIC 80K Cooler, located outside of building 1006B is designed to maintain the RHIC magnet circuit at 80K when the main 24 kW RHIC cryogenic refrigerator is shutdown. The Cooler is located outside of building and to the north of the existing LHe and LN_2 liquid storage tanks. The cooler piping is routed into building 1006B where it connects to the valve boxes and flows through the normal cooling lines for the RHIC magnet circuit. Compressors for circulating the helium are located in 1005H & R and the process outputs are addressed in sections 1.0 – 3.0 of this document

Since RHIC is expected to operate about 37 weeks per year, the 80K Cooler is expected to run for 15 continuous weeks. This reduces the mechanical cycling associated with large temperature changes between the operating temperature of 4.5 K and room temperature. The cooler circulates cold helium gas through the RHIC heat shields and magnets that, in turn, is cooled through a heat exchange with boiling liquid nitrogen (LN_2). Additionally, the cooler will be used to allow isolation of a RHIC sextant for warm-up, repair, and subsequent cool-down.

During operation propylene glycol is used to cool and/or warm electrically driven circulator motors located on the cooler. The glycol cycles through the motors and is air cooled through a radiator. The glycol system contains a total of 50 gallons and has secondary containment in the event that there is a leak in the system. Since the containment is located outside there is an administrative control to check and drain rainwater from the containment. The replacement cycle of the glycol is set for every two years and will be disposed of as industrial waste.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
5.1	Propolyene Glycol	Non-hazardous liquid waste as determined by process knowledge	Waste is drummed and sent to the HWMF for disposal as industrial waste	None
5.2	N_2	Non-hazardous gas as determined by process knowledge	Vented to atmosphere	None

III. Waste Minimization, Opportunity for Pollution Prevention

During the initial effort of baselining the Collider-Accelerator Department processes for Pollution Prevention and Waste Minimization Opportunities each waste, effluent, and emission was evaluated to determine if there were opportunities to reduce either the volume or toxicity of the waste stream. Consideration was given to substitute raw materials with less toxic or less hazardous materials, process changes, reuse or recycling of materials and/or wastes, and other initiatives. These actions are documented in this section of the original process evaluation. Action taken on each of the Pollution Prevention and Waste Minimization items identified can be found in the Environmental Services Division's PEP 2000 Database. Further identification of Pollution Prevention and Waste Minimization Opportunities will be made during an annual assessment of C-A processes. If any Pollution Prevention and Waste Minimization Opportunities are identified they will be forwarded to the Environmental Services Division for tracking through the PEP Database.

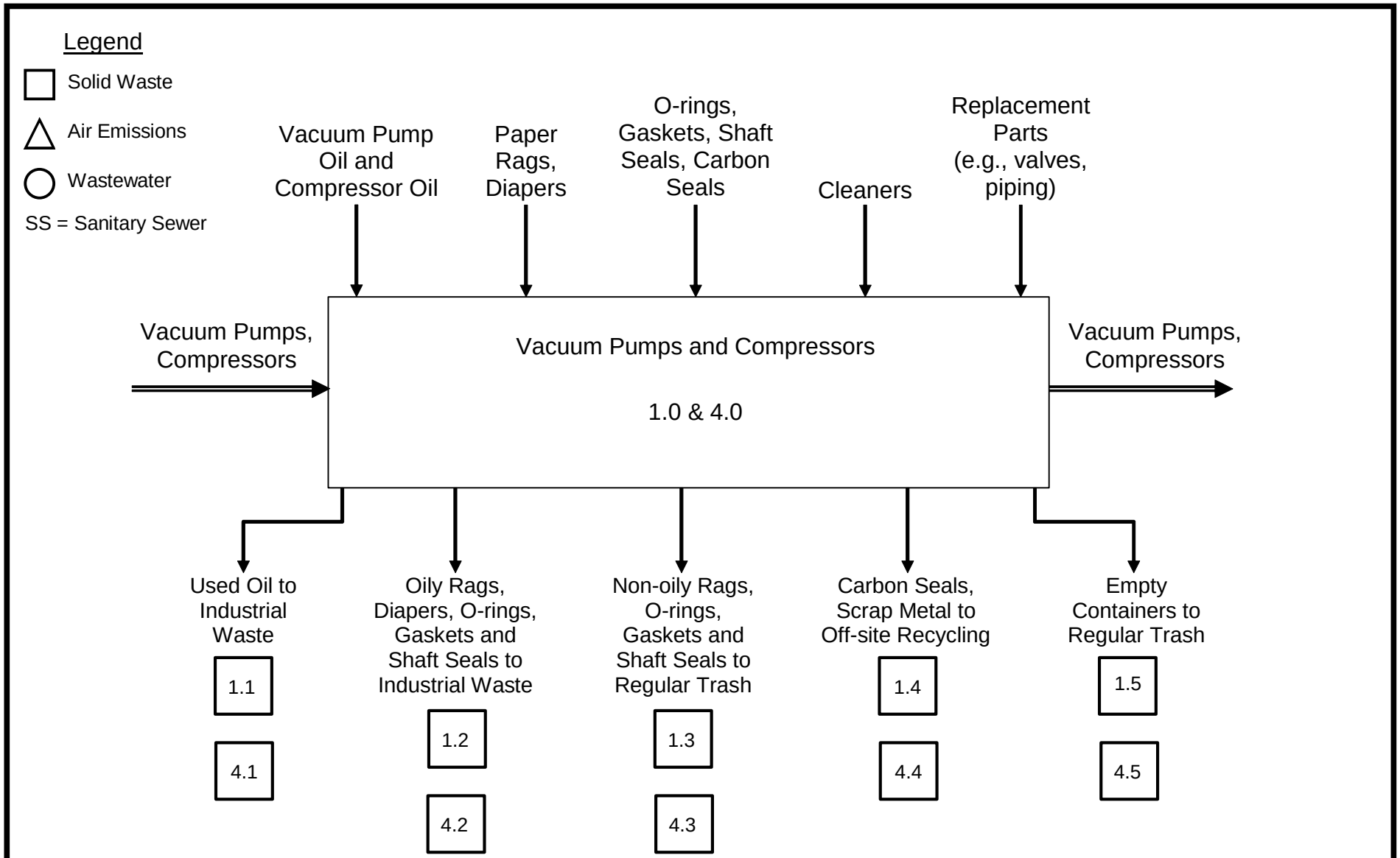
IV. Assessment Prevention and Control

During the initial effort of baselining the Collider-Accelerator Department Assessment, Prevention, and Control (APC) Measures operations, experiments, and waste that have the potential for equipment malfunction, deterioration, or operator error, and discharges or emissions that may cause or lead to releases of hazardous waste or pollutants to the environment or that potentially pose a threat to human health or the environment were described. A thorough assessment of these operations was made to determine: if engineering controls were needed to control hazards; where documented standard operating procedures needed to be developed; where routine, objective, self-inspections by department supervision and trained staff needed to be conducted and documented; and where any other vulnerability needed to be further evaluated. These actions are documented in this section of the original process evaluation. Action taken on

each of the Assessment, Prevention and Control Measures can be found in the Environmental Services Division's PEP 2000 Database. Further identification of Assessment, Prevention and Control Measures will be made during an annual assessment of C-A processes. If any Assessment, Prevention and Control Measures are identified they will be forwarded to the Environmental Services Division for tracking through the PEP Database.

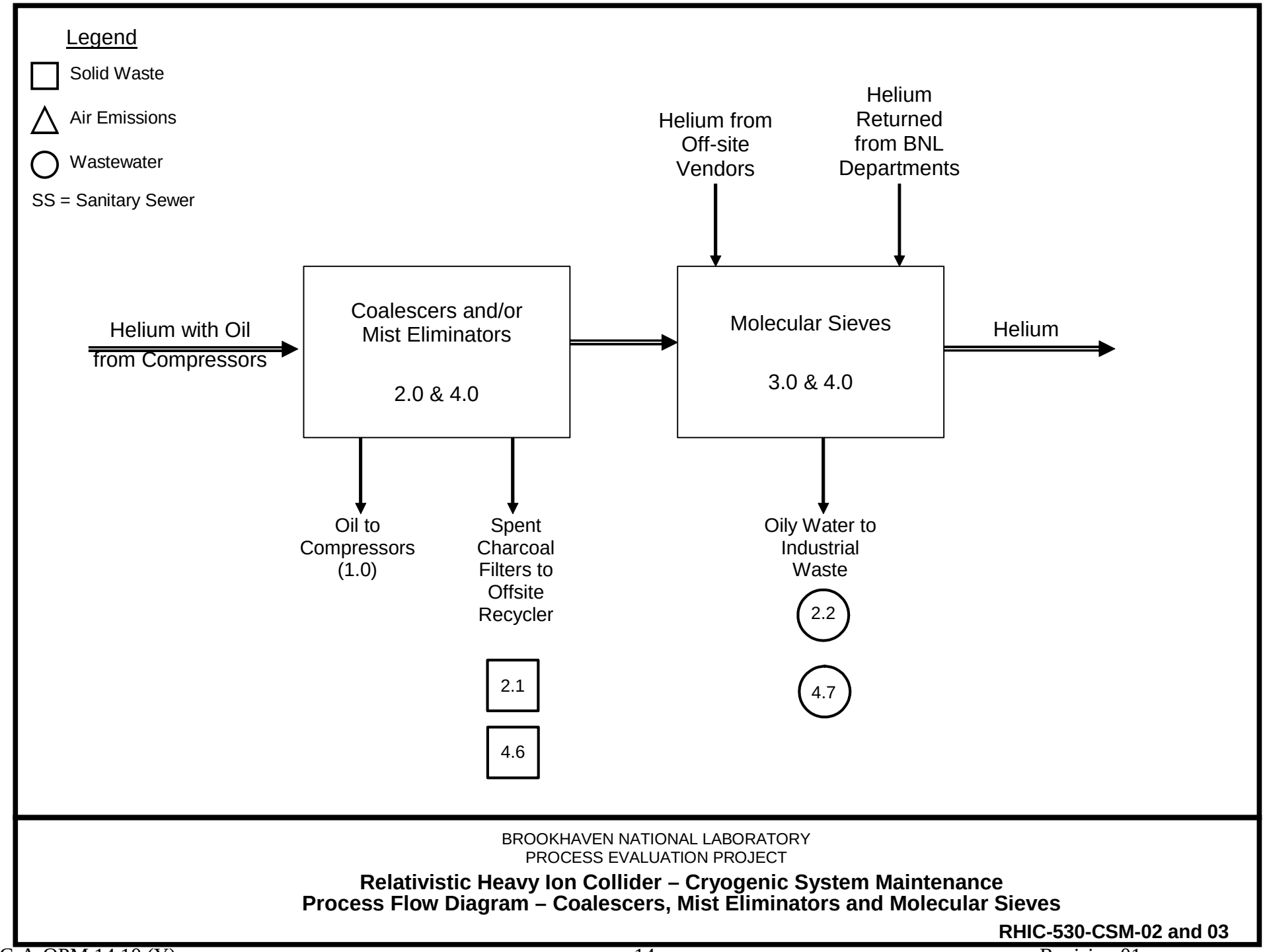
ATTACHMENT 1

PROCESS FLOW DIAGRAMS



BROOKHAVEN NATIONAL LABORATORY
PROCESS EVALUATION PROJECT

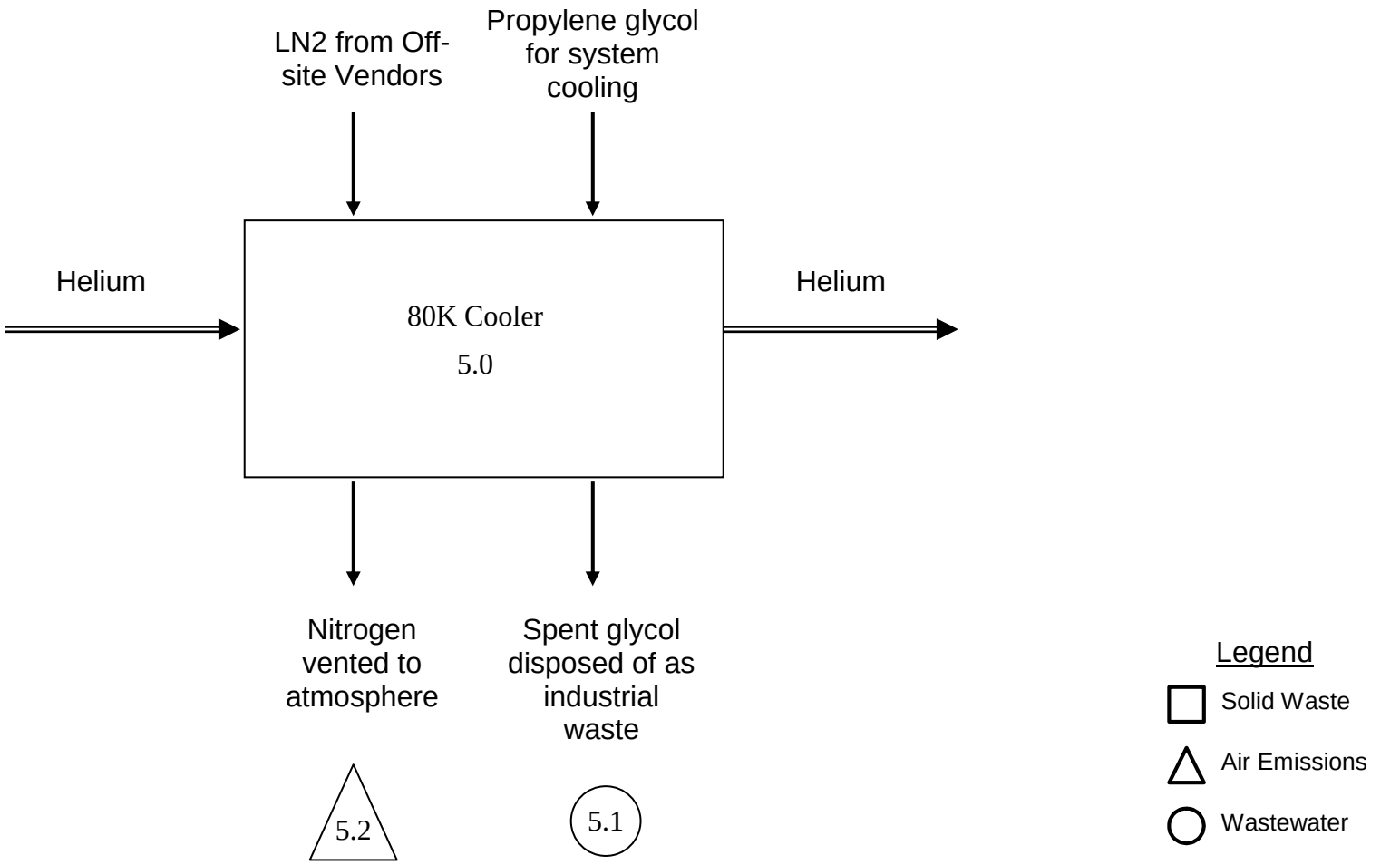
Relativistic Heavy Ion Collider – Cryogenic System Maintenance
Process Flow Diagram – Vacuum Pumps and Compressors **RHIC-530-CSM-01**



BROOKHAVEN NATIONAL LABORATORY
PROCESS EVALUATION PROJECT

Relativistic Heavy Ion Collider – Cryogenic System Maintenance
Process Flow Diagram – Coalescers, Mist Eliminators and Molecular Sieves

RHIC-530-CSM-02 and 03



BROOKHAVEN NATIONAL LABORATORY
PROCESS EVALUATION PROJECT

Relativistic Heavy Ion Collider – Cryogenic System Maintenance
Process Flow Diagram – 80K Cooler

RHIC-530-CSM-04